NAVAL BASE PHILADELPHIA-PHILADELPHIA NAVAL SHIPYARD,
DRYDOCK No. 5
League Island
Philadelphia
Philadelphia County
Pennsylvania

HAER No. PA-387-E

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
P.O. Box 37127
Washington, D.C. 20013-7127

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HISTORIC AMERICAN ENGINEERING RECORD

NAVAL BASE PHILADELPHIA - PHILADELPHIA NAVAL SHIPYARD, DRYDOCK No. 5

HAER No. PA-387-E

Note: The history reports for Drydock No. 4 and No. 5 are identical because these structures were built at the same time using the same technique.

Location:	South end of Bridge Street south of Porter Avenue -Philadelphia Naval Shipyard on League Island at the confluence of the Delaware and Schuylkill Rivers, in the City of Philadelphia, County of Philadelphia, Pennsylvania.
UTM Coordinates:	Zone Easting Northing 18 483535 4415025 Quad: Philadelphia, PA. - N.J. 1:24000
Date of Completion:	1943
Foundation/Construction:	Steel Piles/Concrete
Designer:	F. R. Harris
Engineers/Contractors:	Associates, Philadelphia
Present Owner:	Commander, Naval Base Philadelphia - Department of the Navy
Present Use:	Currently in use. Dock is 1092 feet 6 inches long, 151 feet 8 inches wide and 51 feet 3 inches deep.
Significance:	This rectangular drydock has vertical concrete walls and a flat concrete floor formed on steel pilings. It is an example of a large World War II-era drydock built using the tremie method developed by F. R. Harris, Rear Admiral, U.S. Navy.
Historian:	Robert C. Stewart, July 1994
Project Information:	This documentation project is part of the Historic American Engineering Record (HAER), a long range program to document historically significant engineering and industrial works in the United States. The HAER program is administered by the Historic American Buildings Survey/Historic American Engineering Record Division (HABS/HAER) of the National Park Service, U.S. Department of the Interior. The Naval Base Philadelphia -

Philadelphia Naval Shipyard recording project was cosponsored during the summer of 1994 by HABS/HAER under the general direction of Dr. Robert J. Kapsch, Chief, and by Naval Base Philadelphia, under the command of Rear Admiral Louise C. Wilmot.

The field work, historical reports and photographs were prepared under the direction of project leader Dean Herrin, HAER Historian and Craig Strong, HAER Architect. The recording team consisted of Robert C. Stewart, Historical Archaeologist, West Suffield, CT. The historical section of the report was produced by John Bacon, Philadelphia Maritime Museum and Robert C. Stewart. Jet Lowe, HAER, was responsible for formal photography. The interpretive drawings were delineated by Doug Anderson.

Others who contributed their time, advice, documents and help were: Jane Allen (Philadelphia Maritime Museum), Dan Cashin (Chief, Rigger Apprentice Training), Alfred Cavallero (Manager Design Branch-Public Works Engineering), Rich Chlan (Public Affairs Officer-PNSY), Ed Delany (Fire Administration), Ralph Edelman (Quality Assurance), John Fedak (coppersmith), Robert Gorgone (Deputy Business and Strategic Planning Officer-PNSY), John Hilliard (upholsterer), Ed Jones (Boilermakers), Frank Matusik (Foreman - Lofting), Frank Mellert (Architect - Public Works Engineering), Rosalie Moschella Pinto (Tacker - retired, 26 shop), Paul Niessner (Equipment Specialist - Cranes), Ed Ochmanowicz (Superintendent 31 Shop - Inside Machining), Steve Pandur (Leadingman - Fabric Workers - Sail Loft), Elaine Pelagruto (Beacon Editor), Tom Pierson (Loftsman), Cece Saunders (Historical Perspectives), Richard Scardino (Leadingman -11 shop - ship fitting), Martin Sheeron (Superintendent - Boilermakers), Commander Walter T. Talunas, USNR (Human Resources Transition Coordinator).

For additional information, see the following HAER documentation:

HAER No. PA-387	NAVAL BASE PHILADELPHIA - PHILADELPHIA NAVAL SHIPYARD (Overview, includes bibliography)
HAER No. PA-387-A	NBP-PNSY, DRYDOCK No. 1
HAER No. PA-387-B	NBP-PNSY, DRYDOCK No. 2
HAER No. PA-387-C	NBP-PNSY, DRYDOCK No. 3
HAER No. PA-387-D	NBP-PNSY, DRYDOCK No. 4
HAER No. PA-387-F	NBP-PNSY, 350-TON HAMMERHEAD CRANE
HAER No. PA-387-G	NBP-PNSY, 3,000-POUND CRANE
HAER No. PA-387-H	NBP-PNSY, MANAGEMENT ENGINEERING (Bldg. No. 4)
HAER No. PA-387-I	NBP-PNSY, SUPPLY DEPT. STOREHOUSE (Bldg. No. 5)
HAER No. PA-387-J	NBP-PNSY, COMMANDER'S OFFICE-NAVAL BASE (Bldg. No. 6)
HAER No. PA-387-K	NBP-PNSY, STEEL STOREHOUSE (Bldg. No. 8)
HAER No. PA-387-L	NBP-PNSY, CARPENTRY SHOP (Bldg. No. 14)
HAER No. PA-387-M	NBP-PNSY, MACHINE SHOPS (Bldgs. No. 16 & 18)
HAER No. PA-387-N	NBP-PNSY, MACHINE SHOPS (Bldgs. No. 17 & 19)
HAER No. PA-387-O	NBP-PNSY, FOUNDRY/PROPELLER SHOP (Bldg. No. 20)
HAER No. PA-387-P	NBP-PNSY, STRUCTURAL SHOP (Bldg. No. 57)
HAER No. PA-387-Q	NBP-PNSY, AIRCRAFT STOREHOUSE (Bldg. No. 76)
HAER No. PA-387-R	NBP-PNSY, AIRCRAFT ASSEMBLY SHOP PLANT No. 2 (Bldg. No. 77H)
HAER No. PA-387-S	NBP-PNSY, STRUCTURAL ASSEMBLY SHOP (Bldg. No. 541)
HAER No. PA-387-T	NBP-PNSY, PIPE COPPERSMITH SHOP (Bldg. No. 543)
HAER No. PA-387-U	NBP-PNSY, MATERIAL ASSEMBLY SHOP (Bldg. No. 592)
HAER No. PA-387-V	NBP-PNSY, MAIN SUPPLY WAREHOUSE (Bldg. No. 624)
HAER No. PA-387-W	NBP-PNSY, RESERVE BASIN AND MARINE RAILWAY

DRYDOCK Nos. 4 & 5

In 1927, F. R. Harris, Rear-Admiral, USN, developed the tremie technique of drydock construction. Tremie refers to a technique for pouring concrete under water. This eliminates the problems with keeping the site dry while it is under construction and reduces the possibility of landslides and displacement of the drydock floor from hydrostatic forces.

Harris' method is a relatively simple, safe and efficient construction method for drydock construction. It proved to be a time-saver and allowed the construction of large drydocks in about two years, generally within cost estimates.

Construction began by dredging basins at the sites of Drydocks 4 and 5. The bottom of each basin was covered with a gravel bed 2 feet thick. Pile drivers positioned steel "H" beams in the overlying water and forced them through the gravel bed to a firm soil stratum below the river-bank. These piles were for carrying the loads of the drydock and any ship within it.

Cranes positioned steel tremie forms, extending for the full width of the drydock and its side walls, on the submerged gravel bed. Concrete was pumped into the floor forms. After the concrete had set, tremie forms were positioned at the sides of the floor forms and filled with concrete. When the concrete in the tremie wall forms hardened, the space between the side walls and the excavation was backfilled.

The drydock entrance was blocked with a coffer dam and the water pumped out so work could proceed under dry conditions. Masons formed a concrete lining on the inside of the wall tremie forms as well as on the floor. This compensated for irregularities in tremie form alignment and covered the surface of concrete. It gave a finished appearance to the wall and floor surface.

Wartime ship construction activity was well underway while Drydock No. 4 was being finished. The tremie method allowed six destroyer escorts to be built in the partially finished dock while it was rushed to completion.

The tremie method of drydock construction, as developed by Admiral Harris, allowed drydocks to be built in about two years with predictable costs. The engineering firms of Moran, Proctor, Freeman and Mueser; Parsons, Klapp, Brinkerhoff and Douglas; and Fay, Spofford and Thorndike worked with Harris in developing tremie drydock construction technique.

For a list of related sources, see the bibliography at the end of the written report for HAER No. PA-387, Naval Base Philadelphia - Philadelphia Naval Shipyard.

ADDENDUM TO
NAVAL BASE PHILADELPHIA-
PHILADELPHIA NAVAL SHIPYARD,
DRY DOCK NO. 5
League Island
Philadelphia
Philadelphia County
Pennsylvania

HAER No. PA-387-E

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN BUILDINGS SURVEY
National Park Service
Northeast Region
Philadelphia Support Office
U.S. Custom House
200 Chestnut Street
Philadelphia, P.A. 19106

HAER
PA
51-PHILA,
709E-

HISTORIC AMERICAN ENGINEERING RECORD

NAVAL BASE PHILADELPHIA-PHILADELPHIA NAVAL SHIPYARD, DRY DOCK NO. 5

This report is an addendum to a 4-page report previously transmitted to the Library of Congress.

Location: League Island, Philadelphia
Philadelphia County
Pennsylvania

UTM Coordinates:

Zone	Easting	Northing
18	483535	4415025

Quad: Philadelphia, Pa.-N.J., 1:24,000

Dates of Construction: May 1941-February 1943

Foundation/Construction: Steel piles and tremie forms/Concrete

Designers/Engineers: Dry Dock Engineers (New York)

Contractors: Dry Dock Associates

Present Owners: Department of the Navy
Naval Facilities Engineering Command
10 Industrial Highway
Lester, Pennsylvania 19113-2080

Present Use: vacant

Significance: Dry Dock No. 5 is one of a series of very large dry docks constructed at United States Navy yards during World War II to meet shipbuilding and repair needs. It, along with other contemporary dry docks, was built using the tremie method of concrete construction, developed by Rear Admiral Frederic R. Harris (USN-Ret.).

Project Information: Dry Dock No. 5 has been determined to be a contributing resource within the Philadelphia Naval Shipyard Historic District. It is located in a portion of the shipyard presently under redevelopment as the site of the Kvaerner Philadelphia Shipyard, a commercial shipbuilding operation. Kvaerner plans to reuse Dry Dock Nos. 4 and 5 in its operations. To mitigate changes that would result from reuse, the

Pennsylvania Historical and Museum Commission and the Department of the Navy agreed to record Dry Dock No. 5 to HAER standards.

Preparers of Documentation:

Richard Meyer/Senior Project Manager
Douglas C. McVarish/Project Architectural Historian

John Milner Associates, Inc.
535 North Church Street
Philadelphia, Pennsylvania 19380

1999

Description of the Feature

Dry Dock No. 5 is located at the west end of the shipyard south of Porter Avenue. It is situated to the west of Dry Dock No. 4, with 440 feet distance between the centerlines of the two docks. The two dry docks are very similar, although some differences are evident. Dry Dock No. 5 measures 1,092 feet 6 inch from the head wall to the inner face of the caisson. Its width at coping is 153 feet 4 inches, the governing width at 6 feet above sill is 143 feet 2 inch, and the mean depth from high water to sill is 43 feet 6 inches. The total depth of the dry dock is 51 feet 3 5/8 inches.

The outside walls of Dry Dock No. 5 are constructed of tremie concrete of 15 foot thickness. The bottom of the dry dock is constructed of an 18 foot thickness of tremie concrete, anchored in steel piles. The coping of the dry dock is marked by a steel pipe and chain railing. Angled outward projections of the coping accommodate mooring cleats.

The river end of a dry dock is referred to as its entrance. Typical of dry dock entrances, the side walls of the entrance to Dry Dock No. 5 are angled outward from the base. Such inclined walls facilitate the seating and unseating of the caisson. The bottom of the caisson rests on a seat and bears against a sill. The entrance seat has a line of sheet steel piling located below it to prevent undermining caused by erosion or dredging (U.S. Department of Commerce 1956:2-4).

The entrance to the dry dock is closed by a floating caisson, a watertight structure whose buoyancy can be altered by varying its water ballast. The caisson of Dry Dock No. 5 is constructed of steel and is similar in construction method to that of all-welded steel vessels. The caisson was built by Dravo Corporation, a Pittsburgh-based firm that had substantial experience in building naval craft during World War II. This caisson, sheathed in steel skin plate, measures approximately 157 feet 3 1/8 inches in width, 53 feet 2 inches tall, and 20 feet wide. The ends of the caisson slope inward toward the bottom, and the bottom corners are rounded. The lower portion of the outboard elevation of the caisson slopes inward.

A walkway with steel pipe railings extends across the top of the caisson. This walkway is illuminated by two light standards with paired lamps. The west light standard also contains a red signal light. Two round manholes provide access to portions of the interior of the caisson, while two, slightly raised, rectangular hatches provide access to other areas. These hatches provide access to three flights of ladder-like steel stairs in the interior of the caisson. Two capstans are also placed atop the caisson. These 7.5 horsepower capstans were manufactured by the New England Trawler Equipment Company. Attached 1/2 horsepower "Pacemaker" motors were manufactured by Dings Dynamic.

The machinery of the floating caisson consists of pumps and valves, used primarily to vary the water ballast, and capstans, to aid in moving the caisson while afloat. Sinking valves are operated from control stations, and pump motors drive 15-inch, centrifugal pumps. The water-flow regulation system of the caisson is designed to maintain firm control of list and trim during all stages of sinking and raising operations. The machinery is driven by electrical motors, motors that obtain their power through cables attached to shore connections located next to the caisson seat.

The operation of raising the caisson from its seat is begun when the water level inside the dry dock reaches the level of the water seaward of the caisson. The pumps are started with the seaward discharge valves open, and sufficient water ballast is removed to float the caisson to its desired position. Then the valves are closed and secured, the caisson machinery is shut down, and the caisson is moved outside the dry dock channel limits by tugs and/or capstans.

The operation of closing the entrance to the dry dock is the reverse of the opening operation except that pumps are not used to flood the ballast tanks to sink the caisson. While the caisson is being sunk, it must be kept exactly in its correct position with respect to the sill and have practically no list or trim (U.S. Department of Commerce 1956:2-10-2-11).

The dry dock is flooded through flooding tunnels. The tops of these tunnels lie several feet below low water and are located in the outward face of the entrance walls. The openings of the tunnel are protected by heavy gates or trash racks to prevent debris from entering the tunnel. Flow of water into the flooding tunnel is controlled by sluice gates. Sluice gates move between two parallel, machined metal guides that form part of their frames. The frame is bolted to thimbles embedded in the concrete. The sluice gates for Dry Dock No. 5 are located near the entrance to the flooding tunnel inside the trash rack and stoplogs.

The set of grooves for stoplogs are located in the flared section at the end of the flooding tunnels. The purposes of these stoplogs are to exclude river water from the tunnel system if the sluice gates fail to operate and also to provide dewatered conditions for the performance of maintenance operations on the gates.

The sluice gates are operated by an electric motor. This 440 volt, 3 phase, 60 cycle motor was specified to raise the gates at a rate of no less than one foot per minute. The gate mechanism also permits emergency manual operation. The sluice gate is controlled by a three-position switch with positions for closing, opening, and off. A mechanical indicator shows the amount of opening. The switch and indicator are mounted on the central control board in the pump well.

The filling tunnels or culverts extend from the entrance walls of the dry docks to a point approximately 200 feet north of the entrance wall. The dry dock is filled and emptied through three culvert openings near each side wall toward the entrance end of the dry dock. Each floor opening is fitted with a steel frame grating. The east openings measure 9 feet wide and 20 feet long, while the west openings measure 6 feet wide and 15 feet long. The south openings are placed approximately 129 feet from the lower sill of the dry dock, and the openings are spaced 15 feet apart. At these locations, circular, steel pipes, four feet in diameter, extend from the bottom of the filling culvert to below the floor of the dry dock. The pipes widen to five feet at the bend at the bottom of the side walls and to six feet beneath the floor of the dry dock. The total estimated time needed to flood the dry dock is two hours. The waste water from emptying the dry dock flows through the same floor grates to the pump well through eight foot diameter culverts that extend to the sewage tank in the pump house. An eight foot by nine foot discharge conduit empties the waste water from the pump well into the Delaware River.

Dry Dock Nos. 4 and 5 are dewatered by three 54 inch, 1,200 horsepower, 390,000 gallon per minute dewatering pumps. These are mixed-flow-type, centrifugal units driven by electric motors. The motors, located on the pumphouse floor above the pumps, drive the pumps by means of vertical steel shafts.

These 2,300 volt, 3 phase, 60 cycle squirrel cage motors operate at 1,200 rpm. The total estimated time to dewater Dry Dock No. 5 is 210 minutes. The pumpwell is also equipped with two 16 inch, 250 horsepower, 20,000 gallon per minute, mixed flow type drainage pumps. These pumps are also used to drain Dry Dock No. 4. The pumps are designed to clear the dock floor fairly quickly and to remove leakage. The drainage pumps are powered by 440 volt, 3 phase, 60 cycle, 250 horsepower, moisture-resistant, squirrel cage type motors.

Both side walls of the dry dock also contain pipe tunnels. These tunnels measure 5 feet by 7 feet. Each pipe tunnel contains a six inch diameter fresh water main, a six inch diameter steam main, a six inch diameter air main, and an eight inch diameter salt water main. At various points along the dry dock walls, 4 inch sludge suction pipes connect to sludge pits.

Utilities serving the dry dock include electricity, fresh water, river water, compressed air, steam, oxygen, sanitary sewer, and MAPP gas. Alternating current electricity is of the 3 phase, 60 hertz type and is provided at 460 volts and 14,250 amps. Receptacles include two 4,000 amp buses on the east side and 22 east side and 17 west side receptacles at 400 amps. Fresh water is provided by 6 inch mains capable of providing 800 gallons per minute at 45 psi. Six 1 1/2-inch outlets are provided in the east side wall, ten 2 1/2-inch and seven 1 1/2-inch outlets in the west side wall. River water is provided by 12 inch mains capable of providing 7,000 gallons per minute at 175 psi. River water outlets include 18 4-inch high pressure and 21 2 1/2-inch low pressure outlets on each side. Compressed air is provided by 6 inch mains capable of providing 10,000 cubic feet per minute at 100 psi. The dock is served by one hundred 1 1/4-inch outlets. Steam is provided by 6 inch mains capable of providing 80,000 phr at 100 psi. The dock is served by 25 2 1/2-inch outlets and 24 2-inch outlets. The flow of steam to the various outlets is controlled by a series of gate valves. Oxygen is provided by 2 inch mains that deliver the gas at 460 cubic feet per minute at 100 psi. The dock is equipped with 36 3/4-inch outlets. Sanitary sewer is provided by 8 inch mains capable of handling 3,200 gallons per minute. The sewer is fed by 29 4-inch inlets on each side of the dry dock. MAPP gas is provided by 2 inch mains at 5 pounds per square inch. The dock is equipped with 22 3/4-inch outlets on each side (NFEC 1981:29.3-107).

A service altar recess extends the width of the side walls of the dry dock and the length of the head wall. Access to the service altar is from the first landing of steel stairs that extend down the side walls of the dry dock. The service altar also extends along the head wall of the dry dock. Unlike the head wall service altar of Dry Dock No. 4, this altar is reinforced by a total of 11 equally spaced, concrete columns, square in section, at its outer edge. Recesses in the rear wall of the service apron contain utility boxes, while recesses above the top of the service apron contain spotlights.

As with Dry Dock No. 4, six welding platforms were originally spaced along each side service apron. These welding platforms were serviced by large steel pipes that project from the walls and are fitted with valves. A large pipe for the southeast welding platform extends from the land wall of the caisson. Pipes extend vertically from each service altar down to a horizontal pipe that extends along the lower wall of the dry dock. The original, projecting metal-framed welding platforms have been removed, probably to permit the dry dock to accommodate wider ships.

Steel stairs are presently located at the north and south ends of the east and west wall of the dry dock. The north stairs have three landings, while the south stairs have four landings. The lower west wall of the dry

dock is marked by rows of about eight horizontal pipes. The lower walls of the dry dock are pierced with weep holes, and a vertical strip of blue and white tiles on each wall near the caisson delineates the 48 foot height from the floor of the dry dock. Gutters, ranging in width from two feet to six feet and two feet deep extend along the length of the side walls of the dry dock. These gutters are covered by steel gratings.

A total of nine capstans are provided for Dry Dock No. 5. One is located at the head, one at each side of the entrance, and three on each side of the dry dock. These capstans, each of which is operated by an electric motor, are used for pulling vessels and caissons by means of ropes or cables that wind around the center portion of the capstan barrels. Only the barrel portion of the side wall capstans are exposed. The capstan machinery is located in a protected housing beneath ground level (U.S. Department of Commerce 1956:2-20-21).

In a graving dock, means must be provided to keep a docked vessel sufficiently above the floor level to permit work on her bottom. The vessel must be supported off the floor in such a way that its frame and skin remains unstressed. This requires supports that can be set in differing positions and placed fairly close together. Primary support for vessels in Dry Dock No. 5, as other dry docks, is provided by keel blocks. The exact location of these keel blocks depends on the load distribution of the vessel. In general, the blocks are placed transverse to and under her main keel and are secured to the floor of the dry dock (U.S. Department of Commerce 1956:2-23).

Additional Historical Data

In their history of Naval construction during World War II, the anonymous authors described the state of U.S. Navy yards at the outbreak of World War II:

> The older navy yards, and to a lesser extent the more recent yards, had undergone progressive evolution and piecemeal development during the years, as the ships of the fleet evolved from the frigates and sloops of the Revolutionary days to the complex and varied types of the modern navy. Although they had undergone considerable expansion during World War I, none of the yards were fully equipped to cope with the building and repair requirements of the two-ocean Navy of World War II, and most of them were congested, obsolescent, and poorly arranged (U.S. Navy Bureau of Yards and Docks 1947:169).

Between 1938 and 1945, a total of $590 million was expended for construction and improvements at U.S. Navy yards. These improvements were aimed at providing facilities necessary for a planned large-scale ship construction program. Among the structures built to accommodate increased ship repair and construction were dry docks. The first of the major dry docks funded under these appropriations were at the Puget Sound Navy Yard in Washington State. In 1938, work was begun on a 1,000 foot dry dock, No. 4. A year later, construction began on a second large dry dock at the yard (U.S. Navy Bureau of Yards and Docks 1947:173).

The Navy had used dry docks for ship repair and maintenance for many years, but it was not until the period immediately prior to World War II that dry docks were built for ship construction. An anonymous

article in *Engineering News-Record* cited the advantages of a dry dock over the inclined shipways previously used:

> In a dry dock a ship can be built on a level keel, which simplifies the framing and assembling of the steel structure and eliminates the time consumed in computations and measurements necessary to insure members being in proper relation to each other as is necessary on inclined ways. The speed of erection is also accelerated as less bolting and bracing are required to hold parts in true positions while the riveting or welding is completed. Nor do temporary structural members have to be put into the ship to resist launching stresses as is necessary on way building. Finally, when ships are built in basins, the big guns and superstructures can be installed (limited only by the capacity of the dock cranes), whereas the use of ways requires that the addition of such heavy pieces be postponed until after the ship is launched. Launching from basins merely requires letting water in through tunnels, which are built into the side walls, after which the completed ship merely floats off the keel blocks (Anonymous 1942b:66).

The proposed World War II-era naval ship construction program included five battleships of the *Montana* class with a true displacement of nearly 70,000 tons. The dimensions of these ships were predicated on the availability of the third set of Panama Canal locks. These ships would have a beam greater than the clear space between the crane supports of existing shipways. To construct these vessels, it was necessary to provide either new shipways or shipbuilding dry docks. The latter were selected to avoid the problems and hazards involved in launching such large ships and to gain advantages in ease of access, facility of construction, and simplification of weight-handling operations inherent in the use of dry docks.

Existing dry docks at Philadelphia and other Navy yards were too small to accommodate this construction. Philadelphia's Dry Dock No. 1, built in 1889, is 448 feet long and 88 feet wide. Dry Dock No. 2, built in 1902 to 1908, is 721 feet long and 96 feet wide. Dry Dock No. 3, built in 1921, is 1,003 feet long and 118 feet wide. During World War II, Dry Dock No. 1 was used for construction and repair of destroyers, frigates, submarines, and auxiliary craft; Dry Dock No. 2 for first line cruisers and large auxiliary craft; Dry Dock No. 3 for battleships and first line aircraft carriers (Bureau of Yard and Docks 1945:184).

In the summer of 1940 construction was begun on the first two super-docks, designed to accommodate the construction of large battleships. These docks were built at Norfolk and Philadelphia (Dry Dock No. 4). Both were approximately 1,100 feet long and 150 feet wide. In 1941, construction began on a second shipbuilding dock Philadelphia (Dry Dock No. 5), two similar docks were constructed at the New York Navy Yard, and a similar dock was begun at the Naval Supply Depot, Bayonne, New Jersey. All of these docks were built by the tremie method and were completed in from 17 to 21 months. By comparison, prior dry docks required from three to eight years of construction time (U.S. Navy Bureau of Yards and Docks 1947:174-175).

In 1941, the U.S. Navy had a total of 697 vessels under construction. By July 1, 1942, this total had risen to 3,230. To accommodate these increased demands, the Navy contracted for the construction of 28 shipbuilding and graving docks on the Atlantic and Pacific coasts (Anonymous 1943b:165). Strategy changes dictated the abandonment of the program for building super-battleships and the construction,

instead, of aircraft carriers of the *Midway* class. A substantial number of carriers and other smaller vessels were built in the larger of these dry docks during World War II.

Construction of Dry Dock No. 5 began in May 1941. The basic construction methods used were similar to those employed for Dry Dock No. 4. The two dry docks were constructed in an excavation of about 2.3 million cubic yards of sandy silt made by three dippers, one suction dredge, and two clamshell dredges. The dredging for Dry Dock No. 5 was completed on December 16, 1941. Piling driving was completed by January 19, 1942. The tremie concrete floor was completed on March 28, 1942, while the tremie concrete walls were completed on May 10, 1942. The caisson gate was completed on July 22, 1942 (Spencer 1942). The dry dock was ready for use in February of 1943.

A U.S. Navy publication on the construction of dry docks at Norfolk, Virginia, and Philadelphia described the process of dry dock construction:

> The first major operation was to dredge out a basin about 70 feet deep in which the dock could be constructed. This huge excavation was performed by months of incessant work with dipper dredges. On completion of this task, thousands of steel piles were driven into the soft earth bottom to help support the great weight of the ship when it is in dry dock and to help anchor down the dock when it is empty.
>
> Upon these piles were next lowered the steel boxes which formed, section by section, the bottom of the dry dock--into these boxes was then poured the concrete, by using tremies or pipes. This concrete hardened under the water into a rigid slab. Similar steel boxes were placed and filled with concrete to form walls....
>
> The next few months were full of noisy activity as the rough underwater concrete was cleaned off to receive smooth layers of concrete lining and as the walls of the dock were topped with an intricate concrete section containing pipes and conduits for water supply, compressed air, electricity, and other services.
>
> Meanwhile, along the sides of the dock, construction of auxiliary structures was started. This work included crane runways to carry the huge overhead bridge cranes for shipbuilding and repair, tracks for the transportation of materials to and from the dock, quay walls by the mile, submerged pump chambers for housing large pumps which will be able to drain the dock in a few hours' time and numerous other structures (Prentis, Swenson, and Mitchell 1941:n.p.)

The process of tremie dry dock construction is described in detail in the historical data for Dry Dock No. 4 and the appended journal articles. Differences in construction techniques between the two dry dock were summarized by the inventor of the tremie method of dry dock construction, Frederic R. Harris, in a 1942 *Civil Engineering* article:

> For the second dry dock at Philadelphia modifications have been made to further expedite the construction. One was to raise the top of the tremie concrete wall to its maximum wherever possible, about mean tide, and to raise the form above mean high water. This

> will permit the construction of the upper part of the wall in sections at low tide without waiting for the unwatering of the dock. The other modification was to make the line of the inside face of the tremie concrete wall the finish line, and to remove the tremie wall form on the inside, after unwatering, thereby eliminating the wall lining and saving time (Harris 1942:312).

In the construction of Dry Dock No. 5, the concrete plant was moved to the center line at the head of the docks, and two more concrete pumps were installed as boosters (Young 1941:104).

Dry Dock No. 5 is 3 feet 6 inches deeper than Dry Dock No. 4. The increased depth was intended to better accommodate battleships planned for construction at Philadelphia. In a memo to the Chief of Naval Operations, the Commandant of the Philadelphia Naval Shipyard cited the reasons for the proposed enlarged dry dock:

> BB67 and BB68 are now assigned for building at this Yard and, since their construction is one of the principal factors in the design of these docks, it is to be noted that no other dock at this Yard, other than Dry Docks #4 and #5, is suitable for the docking of the BB67-71 class... (Commandant 1941:3).

To accommodate ships of the BB67-71 class in intermediate load conditions, he recommended that 7 feet be added to the depth of Dry Dock No. 5. The final decision was to increase the depth of Dry Dock No. 5 by half this amount. L.B. Combs of the Bureau of Yards and Docks cited the reasons for this decision:

> A preliminary analysis indicates that the dock can be deepened about 3 ft. 6 in. without radically changing the design, and that this would involve a delay of about two months and an additional cost of approximately one million dollars. This would result in a depth at MHW of about 39 ft. 6 inches over 4-ft. high blocks.
>
> If the depth of Dry Dock No. 5 were to be increased 7 ft. as recommended in the basic letter, it would involve a radical change in design, the scrapping of considerable steel fabrication and under order, a delay of about seven months in completion of the dock and an increase in cost of about 3 1/2 million dollars (Combs 1941).

Combs's intermediate recommendation was adopted. Ironically, BB-67 (*Montana)* and BB-68 (*Ohio)* were both canceled before the keels were laid (USS Salem web site).

The consulting engineers for Dry Dock No. 5 were a combination of engineering firms composed of Frederic R. Harris, Inc.; Moran, Proctor, Freeman and Mueser; Parsons, Klapp, Brinckerhoff & Douglas; and Fay, Spofford & Thorndike. The consortium was known as Dry Dock Engineers, and its offices were located at 27 William Street in New York City. Contractors for the dry dock were Spencer, White & Prentis, Inc.; Foley Brothers, Inc.; and Merritt-Chapman & Scott Corporation (Prentis, Swenson, and Mitchell 1941:n.p.).

Photographs in RG 71, Bureau of Yards and Docks, National Archives, illustrate some of the maintenance and repairs to the dry dock after its construction. The suction inlet walls were reinforced with steel

shoring and bracing in 1944. In 1946, repairs were made to the sluice gate to reduce water leakage at its top. In 1947, repairs were made to the concrete of the side walls. This concrete had cracked and spalled in numerous places.

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Primary and Unpublished Sources

Combs, L.B.
1941 Second Endorsement, from Chief of the Bureau of Yards and Docks to Chief of Naval Operations. File No. NY4/N16-1. October 25, 1941. Bureau of Ships correspondence files. RG 19. National Archives Textual Records Branch, College Park, Maryland.

Commandant, Philadelphia Naval Shipyard
1941 Memorandum to Chief of Naval Operations concerning Docking Battleships in the new Shipbuilding Dry Docks #4 and #5, Navy Yard, Philadelphia, Pa. October 9, 1941. File No. NY4/N16-1. October 9, 1941. Bureau of Ships correspondence files. RG 19. National Archives Textual Records Branch, College Park, Maryland.

Engineering Drawings

Collection of approximately 70 linen engineering drawings prepared by Dry Dock Associates, Inc. and Frederic R. Harris, Inc., 1941, at Cushman & Wakefield, Inc., Building No. 501, Philadelphia Naval Business Center. Later maintenance drawings are also contained in the same collection.

Collection of approximately 100 engineering drawings on microfilm. These drawings were primarily prepared by Dry Dock Associates, Inc. and Frederic R. Harris, Inc., 1941 and some duplicate those on file at Building No. 501. RG 71, microfilm roll 99. Cartographic Branch, National Archives, College Park, Maryland.

Historic Views

Approximately 20 photographs of Dry Dock No. 4, 1941 to 1947. RG 71, Prints and Photographs Branch, National Archives, College Park, Maryland. (Representative illustrations are reproduced on pages 18 to 29 which follow.)

Secondary and Published Sources

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1942a Navy Drydocks Make Construction History. *Engineering News-Record.* March 26, 1942: 48-49.

1942b Twin Drydocks Constructed Under Water. *Engineering News-Record.* November 19, 1942:66-73.

1943 Graving-Dock Construction Under Water. *Engineering.* August 13, 1943.

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1941 *Dry Dock Construction, Norfolk, Va., Philadelphia, Pa.* Illustrated by Lili Réthi. United States Navy Bureau of Yards and Docks, Washington, D.C.

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1981 *Drydocking Facilities Characteristics.* Design Manual 29.3. NAVFAC DM-29.3. November 1981. Naval Facilities Engineering Command, Alexandria, Virginia.

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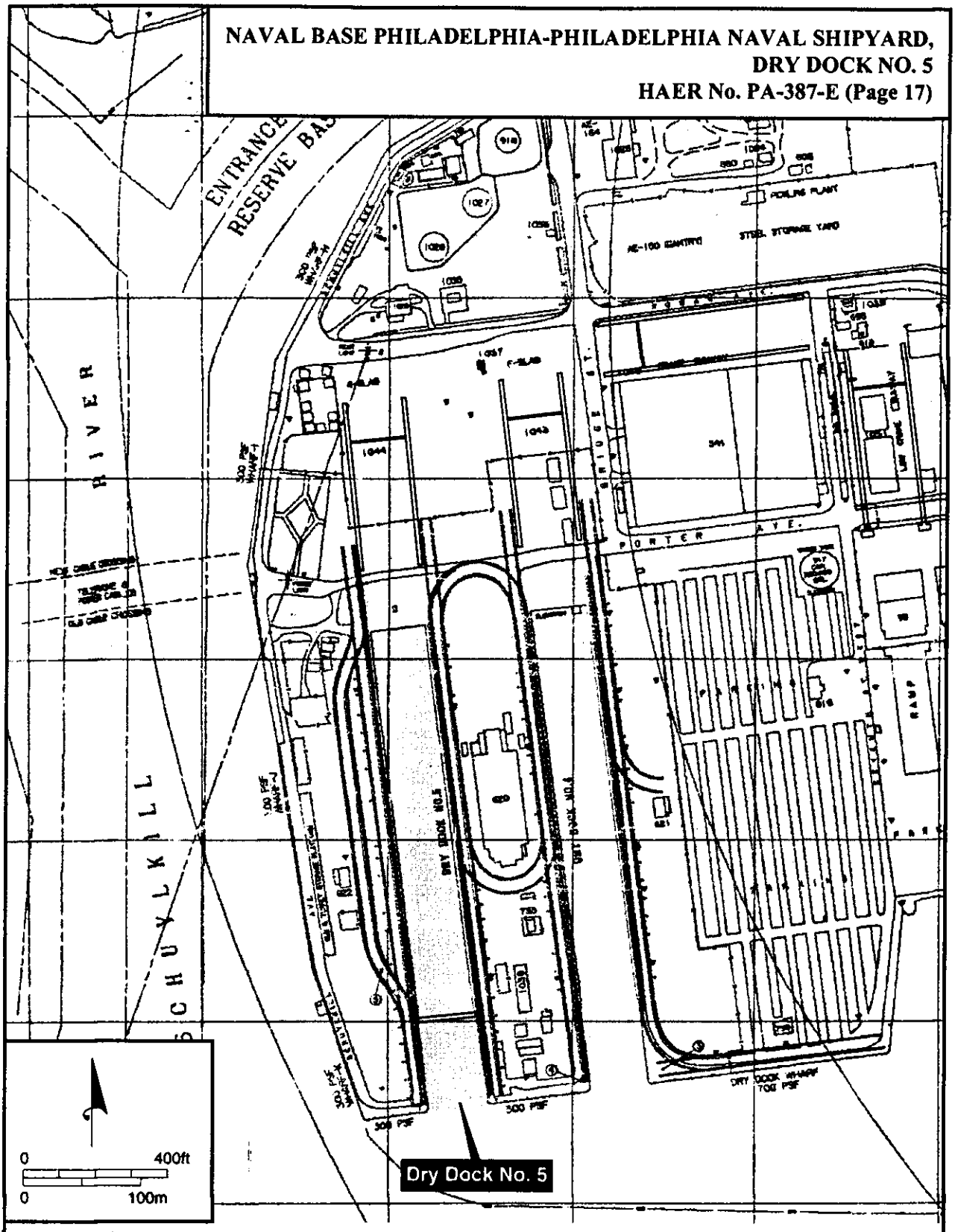
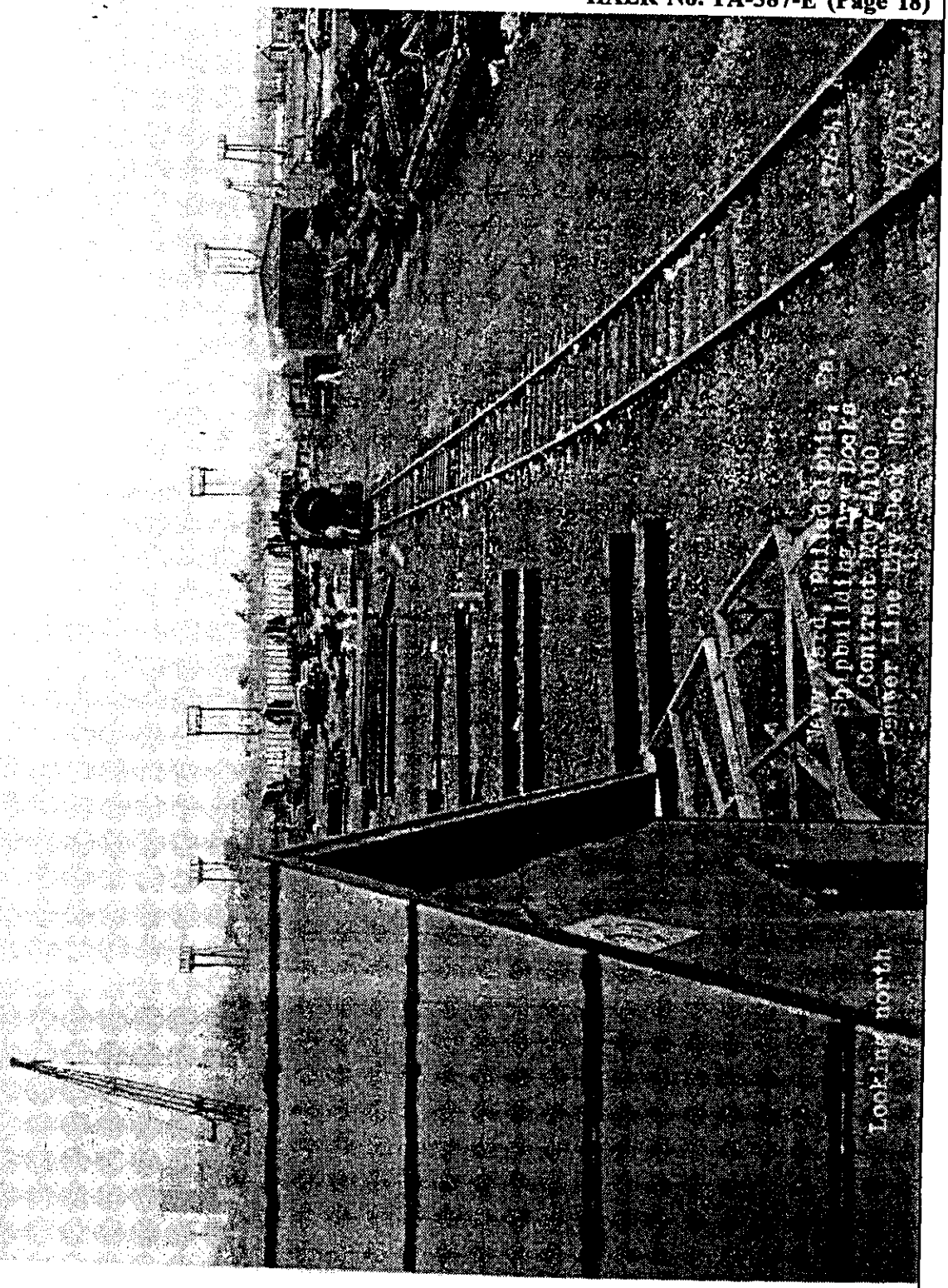
USS Salem Web Site
1998 *Dictionary of American Naval Fighting Ships* database. www.uss-salem.org/danfs

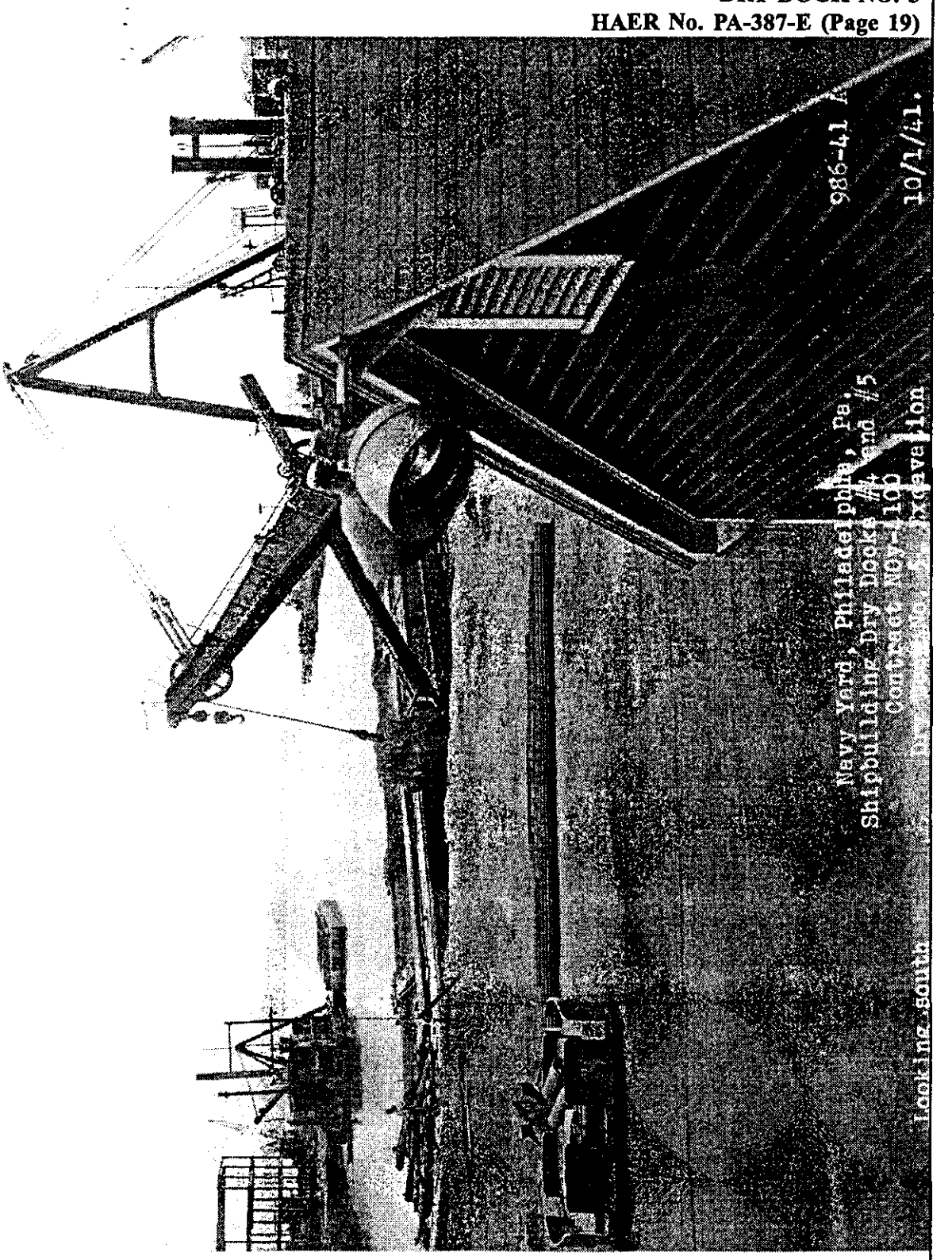


Plan of west end, Philadelphia Naval Shipyard, showing location of Dry Dock No. 5.

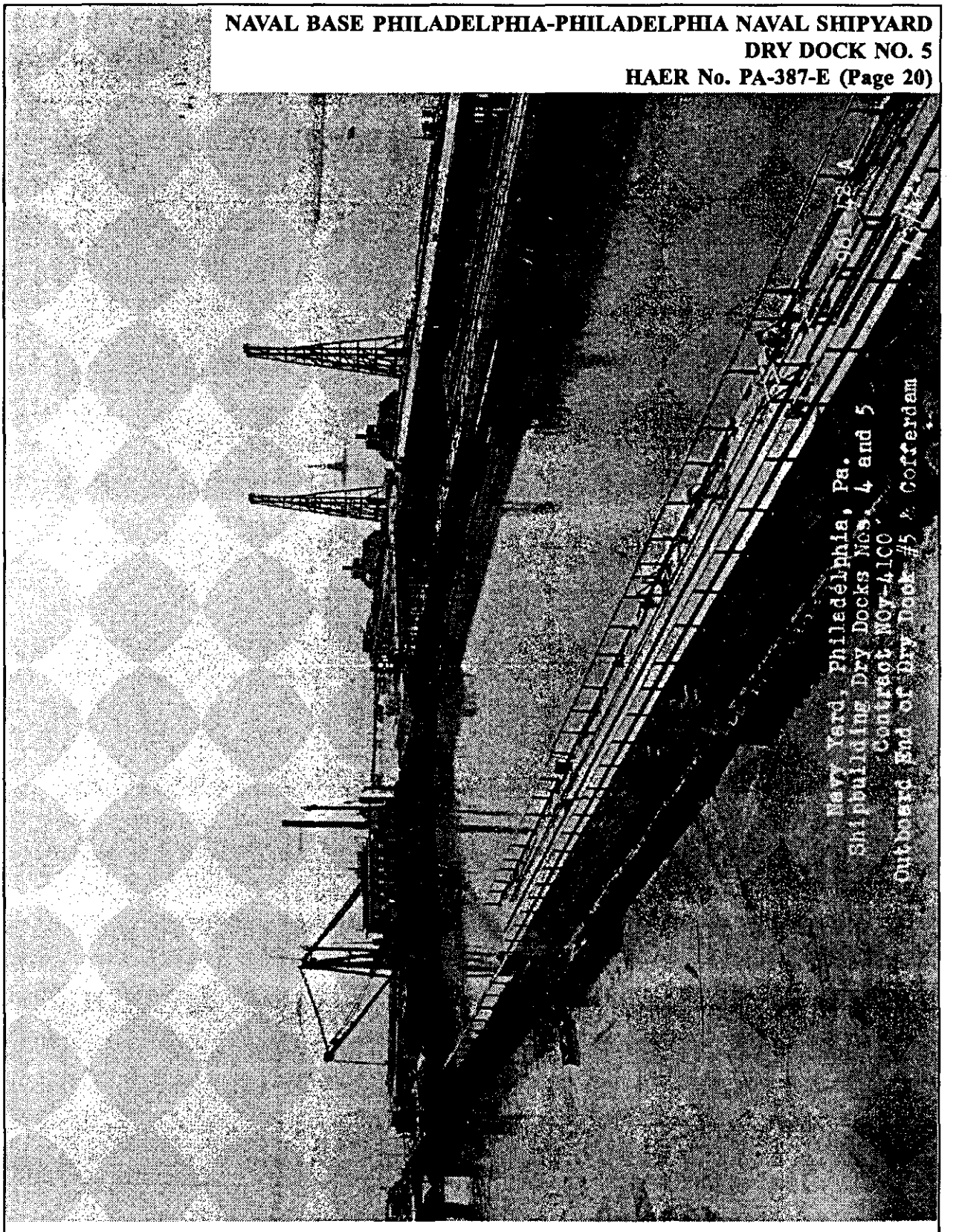


Center line of Dry Dock No. 5. Looking north. June 3, 1941.

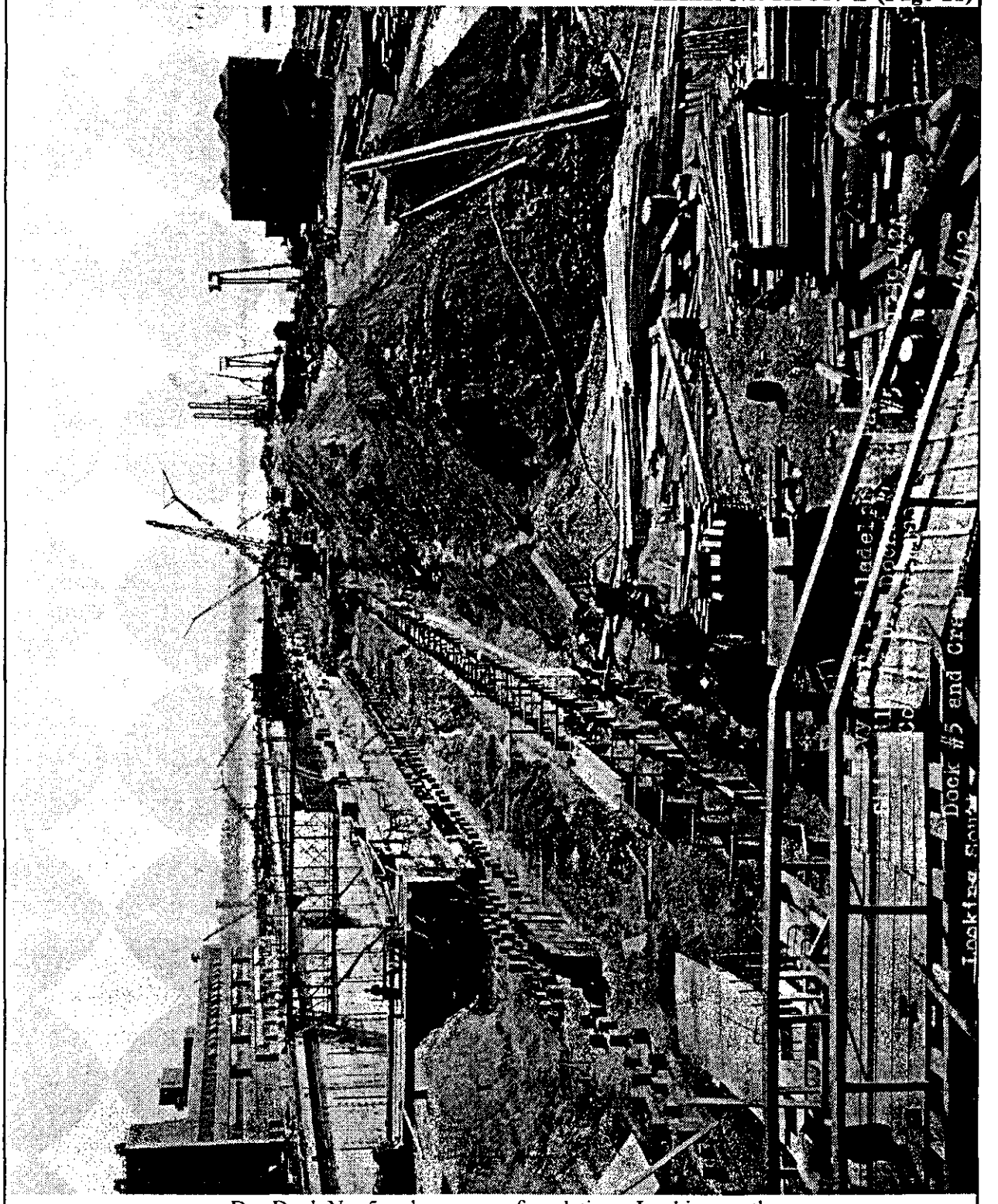
Original at Prints & Photographs Branch, National Archives, College Park, Maryland (RG71)



Excavation for Dry Dock No. 5. Looking south. October 1, 1941.

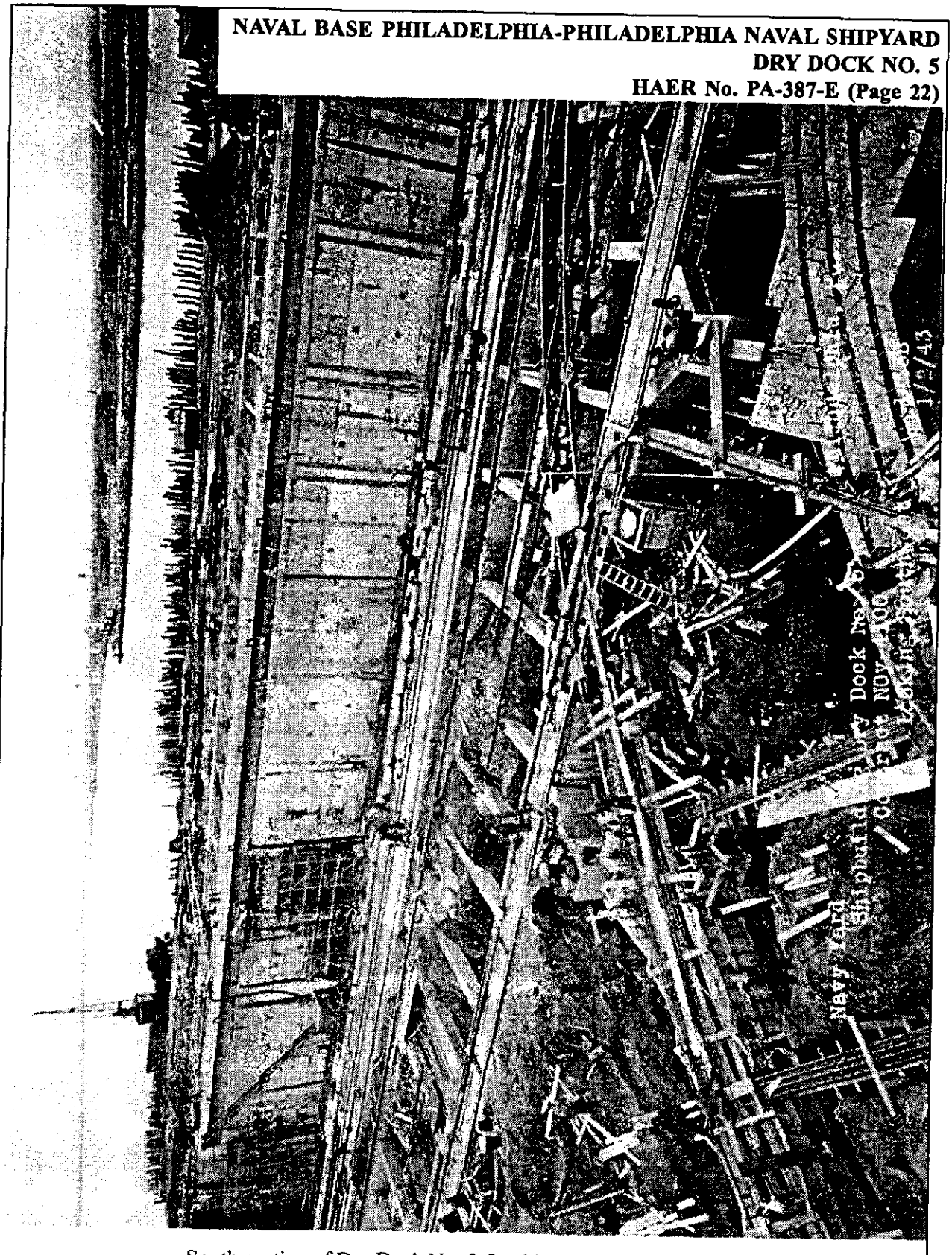


Outboard end of Dry Dock No. 5 and cofferdam. July 3, 1942.



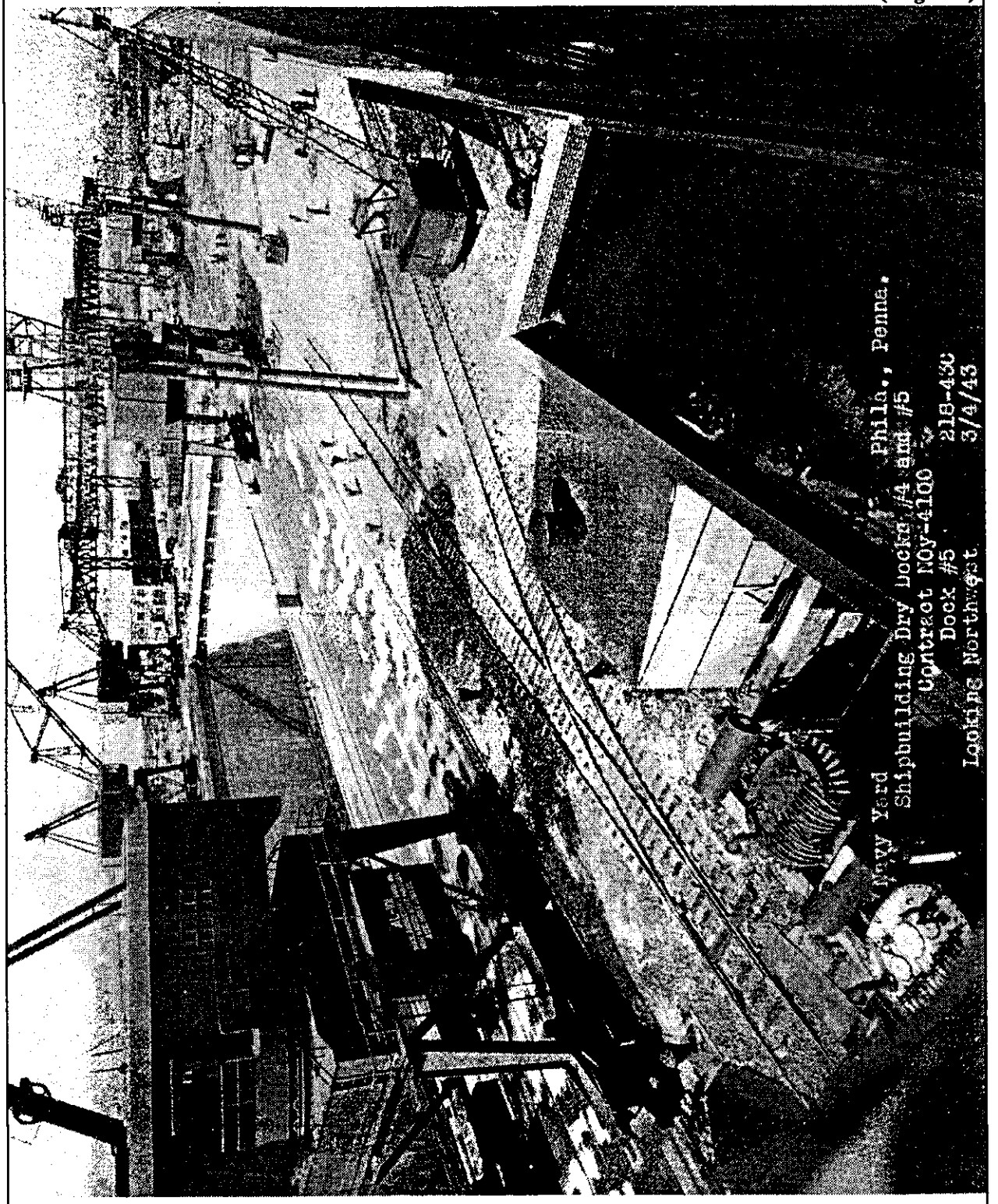
Dry Dock No. 5 and craneway foundations. Looking south.
Service Building (Building No. 620) at left. September 3, 1942.

NAVAL BASE PHILADELPHIA-PHILADELPHIA NAVAL SHIPYARD
DRY DOCK NO. 5
HAER No. PA-387-E (Page 22)



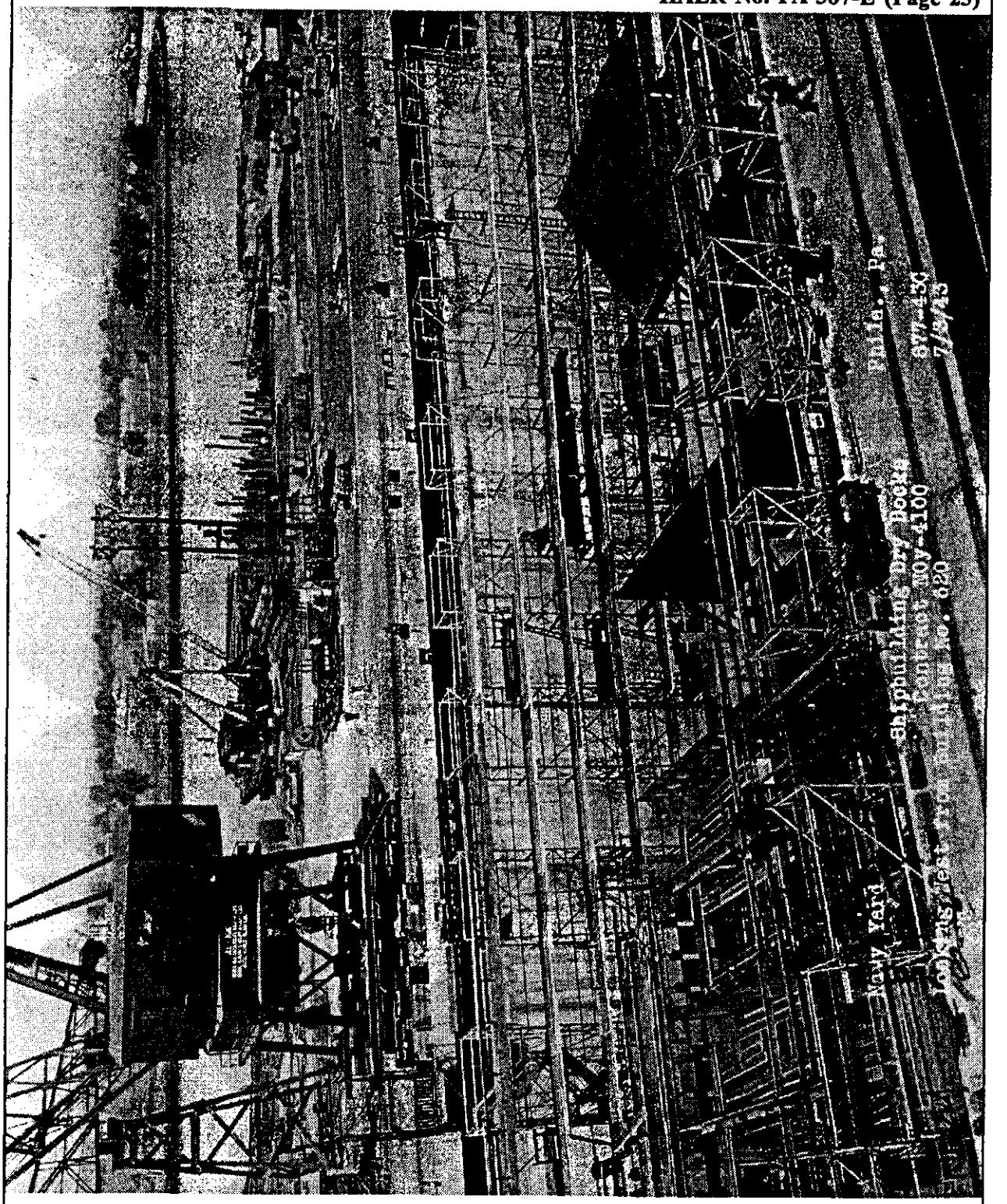
South portion of Dry Dock No. 5. Looking southwest. January 2, 1943.

Original at Prints & Photographs Branch, National Archives, College Park, Maryland (RG71)

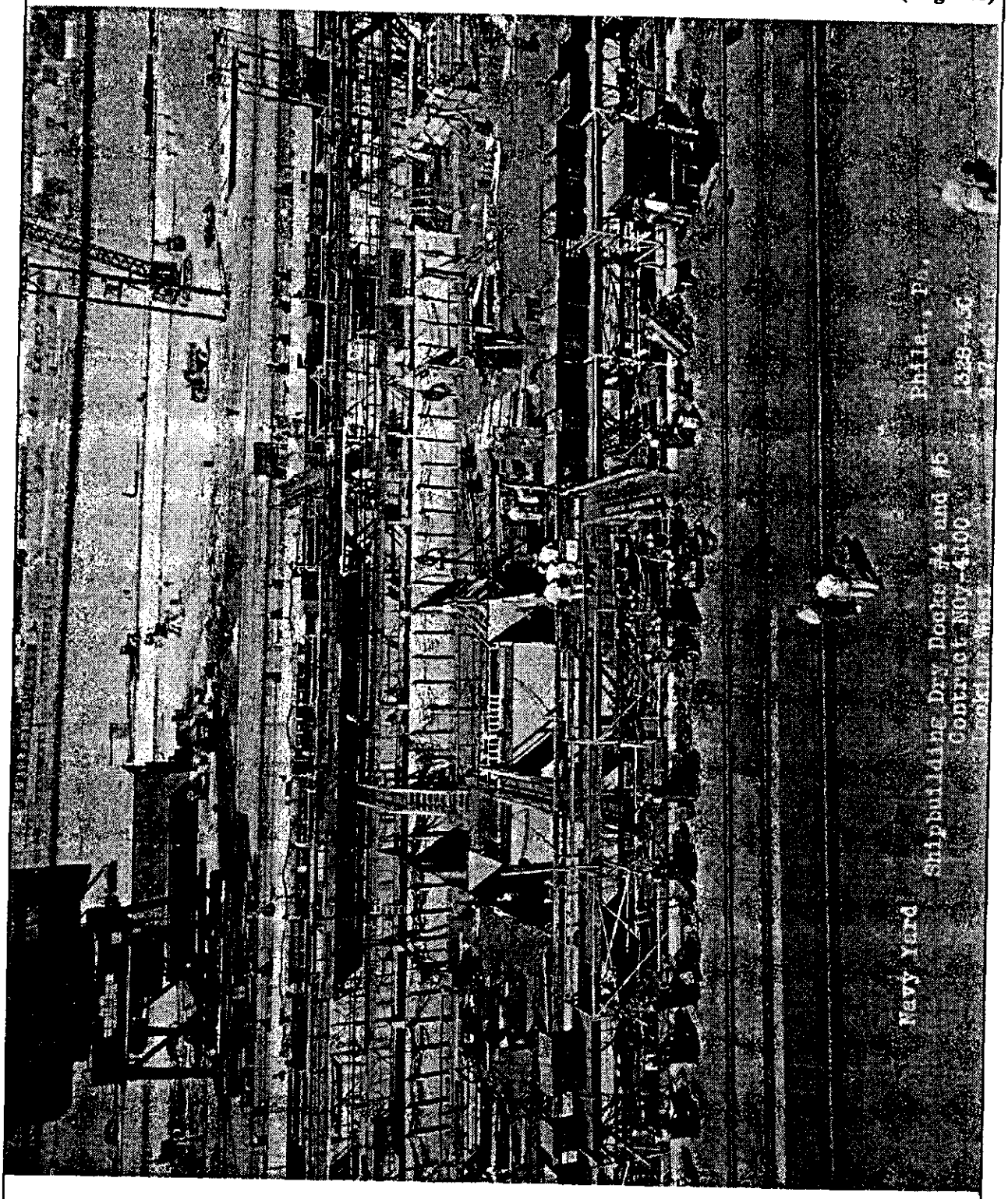


North end of Dry Dock No. 5 and Crane AL-101. Looking northwest. March 4, 1943.

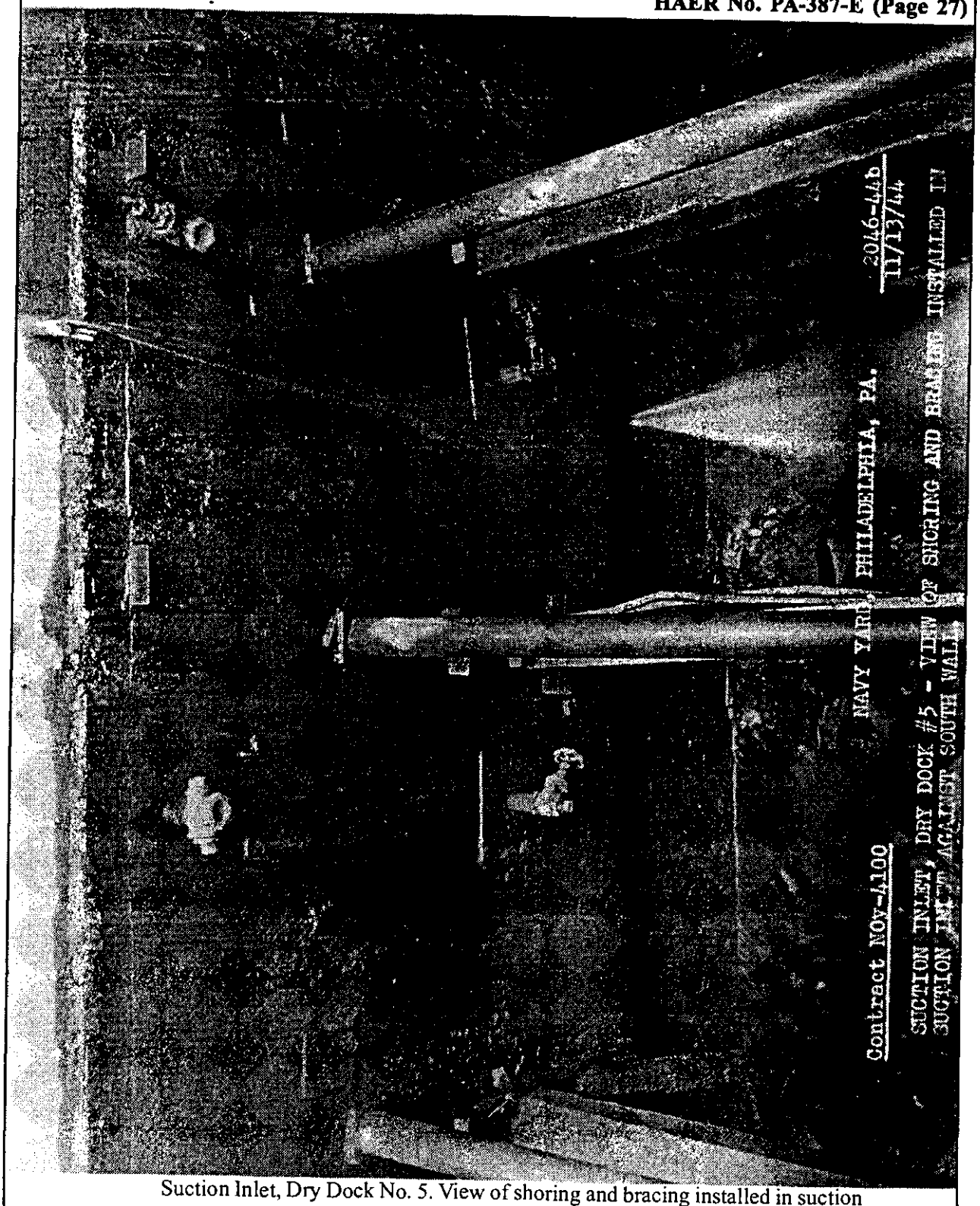
South end of Dry Dock No. 5. Note welding platform on far wall. Looking southwest. May 5, 1943.



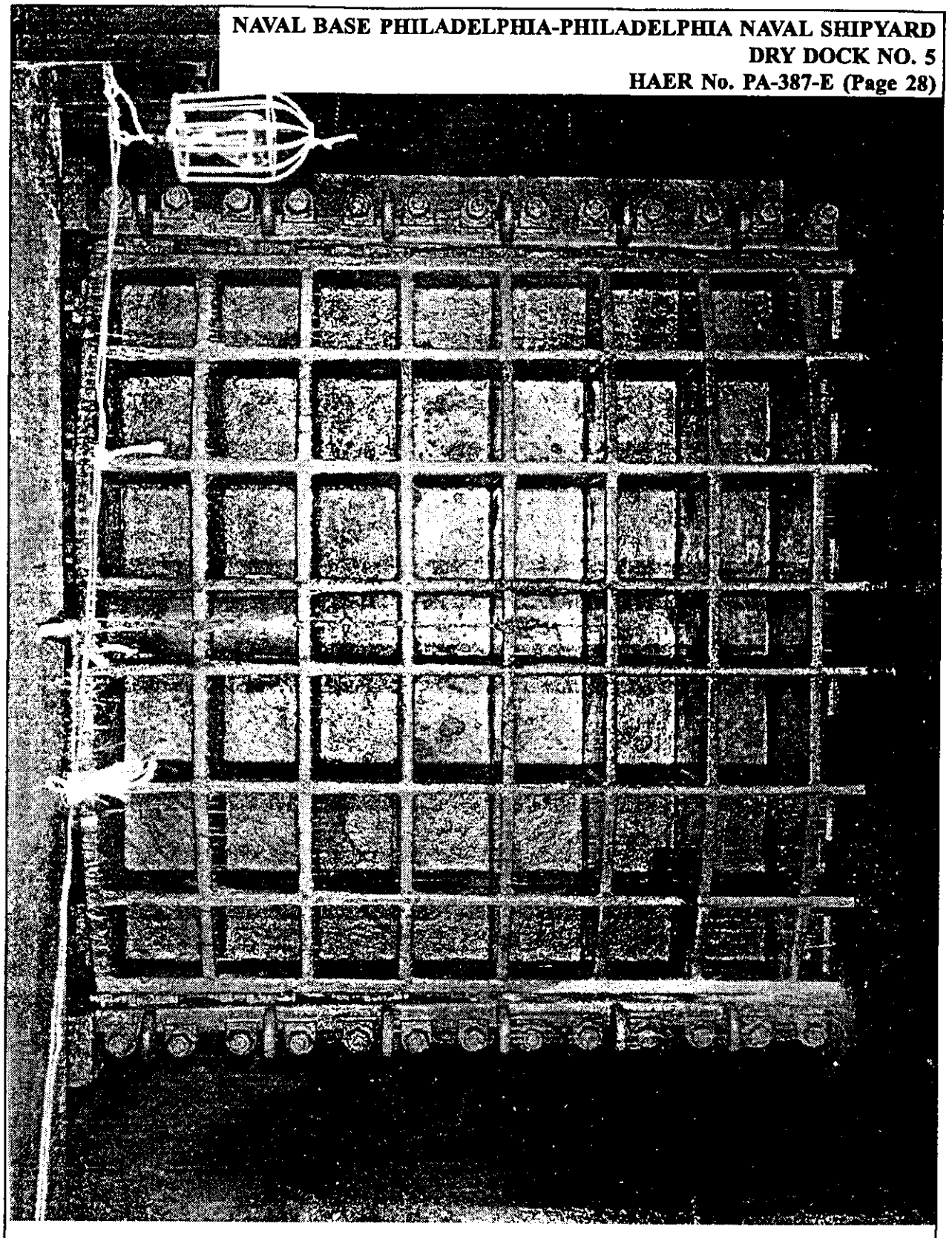
Central portion of Dry Dock No. 5. View west from Building No. 620. July 3, 1943.



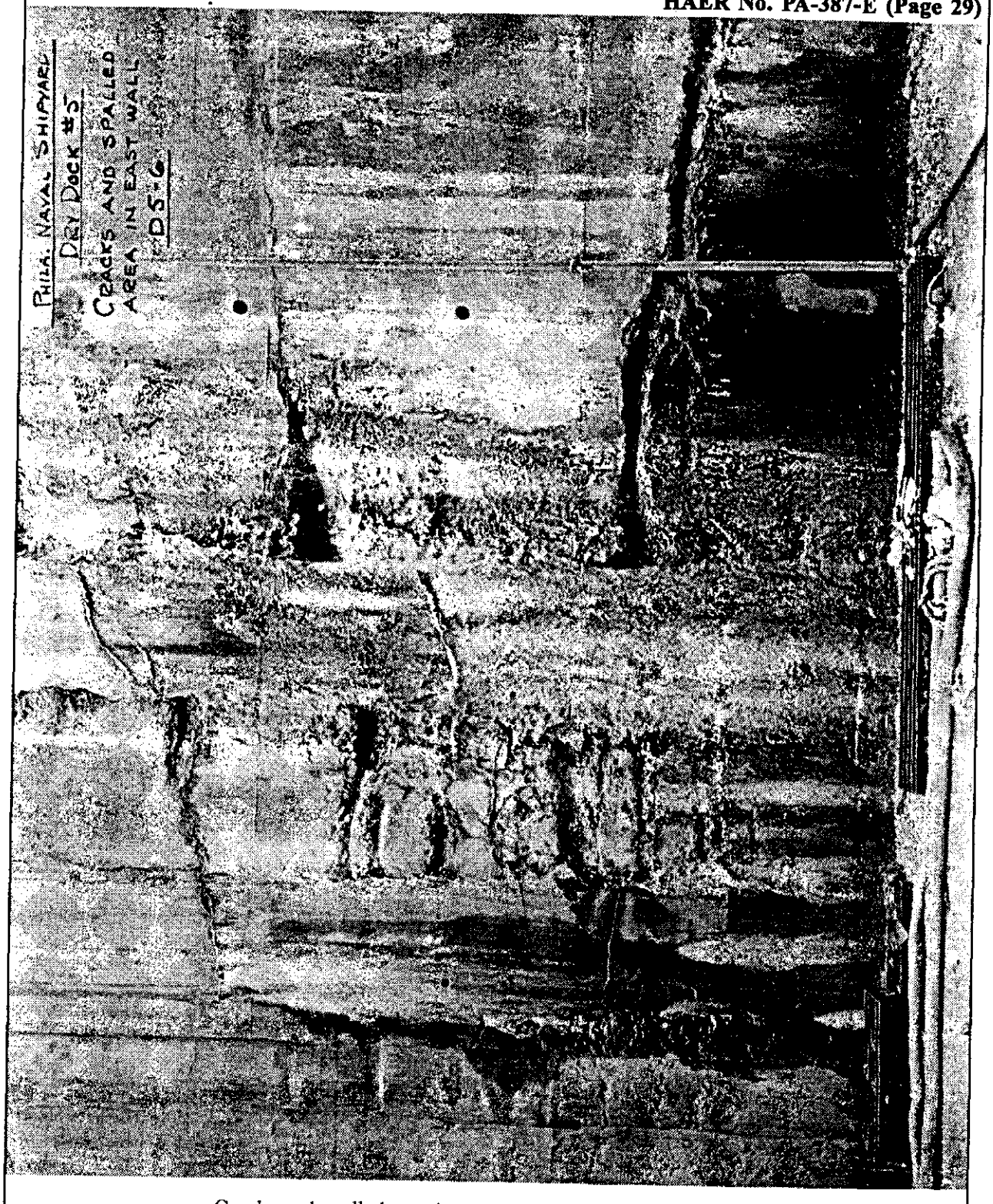
Ship construction in Dry Dock No. 5. Looking west. September 7, 1943.



Suction Inlet, Dry Dock No. 5. View of shoring and bracing installed in suction inlet against south wall. November 13, 1944.



View of Dry Dock No. 5 sluice gate showing leakage at top. September 5, 1946.



Cracks and spalled area in east wall, Dry Dock No. 5 (1947).